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COMPARISON OF POWER OUTPUT'S OF DIFFERENT BLENDS OF PYROLYSIS PLASTIC OIL & DIESEL WITH PURE DIESEL ON SINGLE CYLINDER 4-S (VCR) DIESEL ENGINE

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ABSTRACT

An experimental study was conducted, to compare the powers outputs of pure diesel with different blends of Pyrolysis plastic oil and diesels. Waste plastic through thermal treatment can be derived into liquid fuel or waste plastic oil. Pyrolysis a thermo chemical process is being used as a technology to manage plastic wastes like, High-density polyethylene (HDPE). High density polythene (HDPE) is used in making oil containers, bottles, toys etc. Pyrolysis method is used to prepare Pyrolysis plastic oil from waste plastic oil. Single cylinder four stroke VCR (variable compression ratio) diesel engine is used for testing purpose. Testing of pure diesel is done for reference point. Blends of Diesel and Pyrolysis plastic oil (i.e., 90 and 10, 80 and 20, 70 and 30) were used in volumetric percentage. Fuels were tested at five different conditions of load in % (i.e., 0, 25, 50, 75 and 100). Engine powers were recorded for different fuels. The overall performance of all blends is very satisfactory. P20 has the most satisfactory data out of all blends in terms of indicated power and brake power. Pyrolysis plastic oil can be used as an alternate fuel to reserve the stocks of diesels. It provides same power output result as diesel when used in proportion to form blends with diesel.

KEY WORDS: Plastic Pyrolysis oil, Blend, Alternate fuel, High Density polyethylene & Engine power

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Original Article

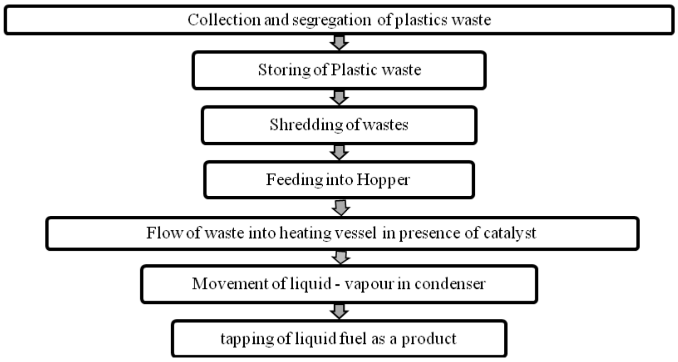
INTRODUCTION

Environmental concern and crisis of petroleum fuels in the past decade have turned the mankind interests in the search for alternate fuels for internal combustion engines. Plastics have become essential materials in today's world and their applications in the industrial and domestic field are continually increasing. Hence, on the other hand, waste plastics create a serious environmental challenge because of their huge quantities and their non-biodegradable nature. So dumping of waste plastic is not a good and permanent solution. The waste to energy technology is one of the recent trends in minimizing not only the waste disposal but also to process the potential materials like plastic to be oil.

Pyrolysis technology is thermal degradation process of the large molecular weight polymer carbon chains in the absence of oxygen. Pyrolysis process is used to produce liquid fuel similar to diesel from plastic waste. Plastic wastes under pyrolysis can be decomposed into three fractions: gas, liquid and solid residue. Different types of plastics require different temperatures for cracking down and to convert into oil. The plastic waste is gently cracked by adding catalyst and the gases are condensed in a series of condensers to give a low sulphur content

distillate. The advantage of the pyrolysis process is its ability to handle unsort and dirty plastic. Plastic is needed to be sorted and dried. Pyrolysis is also no toxic or environmental harmful emission unlike incineration. Without any changes in the engine the pyrolytic oil generated from waste plastic can be used as an alternate fuel**.**

The process of oil from waste plastics takes place as:-



Effect of Various Factors on Pyrolysis

- The chemical composition of feed: The structure and chemical composition of the plastic used in pyrolysis directly influence the products of pyrolysis.
- Heating rates and temperature: With the increase in temperature the polymer is cracked but not every type of polymer can be cracked with increase in temperature.
- Reactor type: Type of reactors is Batch Type, Semi-Batch Type and Continuous and it greatly influences the process.

Advantages of Pyrolysis

- Reduction in volume of waste.
- All the three types of fuel like solid, liquid and gas can be produced,
- The fuel obtained can be stored and transported easily.
- The problems related with environment are greatly reduced,
- Energy can be derived from renewable sources like municipal solid waste or sewage sludge,
- It involves low capital cost.

MATERIALDS AND PROCESS DESCRIPTION

The plastic used in this study was used waste plastic containers (High-density polyethylene-HDPE) for domestic purposes. HDPE has less branching and thus has a higher strength[5]. Due to its good strength, HDPE is used in making oil containers, bottles, toys and more. It is the third largest plastic type found in solid waste category. Waste plastics were cleaned with detergent and water to remove contained foreign materials such as mud and oil. Washed out waste plastics were dried and cut into small pieces in the range of 0.5 inches to 2 inches by using scissor. Plastic waste is treated in a cylindrical reactor at temperature of 300ºC – 500°C at atmospheric pressure for 3 hours. The product output consists of 60-80% pyrolysis plastic oil, 5-10% residue and the rest is pyrolysis gas on weight basis.

Table 1: Properties of Fuel

Property	Units	Diesel	Pyrolysis waste Plastic oil
Chemical Formula	-	$C_{12}H_{26}$	-
Calorific Value	KJ/kg	43350	45409
Ignition delay period	Sec	0.002	-
Colour	-	Red/Orange	Orange
Density at 15 ˚C	Kg/m3	2.7	5.8
Total Fat in 100 g	%	815	785.6
Solubility in Water	-	Nil	
Cetane No.	-	47.0Insoluble	Nil Insoluble

EXPERIMENTAL SETUP

Computerized single cylinder, 4 strokes, direct injection, water cooled VCR (Variable Compression Ratio) Diesel Engine Test Rig is used. An engine indicator is fitted in control panel which sense pressure and crank angle data interface with computer. The engine and Dynamometer was interfaced to a control panel.

Performance Analysis Software "IC Engine Soft Ver. 9.0 Supplied by test rig supplier" Apex Innovation Pvt Ltd" was used for recording the test parameter engine power such as Indicated Power, Brake Power and Friction Power. The Calorific Value and Density of pyrolysis plastic oil as per given testing report by Trimurti Enterprises Indore (Madhya Pradesh) is 45409 kcal/kg and 785.6 respectively. Engine is operated at five different load condition i.e., no load, 25% load, 50% load, 75% load and at full load. The engine runs at different loads in kg (i.e., 0, 2, 4, 6 and 8). All four fuels were tested at five different load conditions. The error in load of + 0.30 kg is considered. The test is done in central analytical laboratory A. B. Road Indore (Madhya Pradesh). Engine powers of these blends were calculated and recorded and it's compared with pure diesel. The entire tests have been performed in IC Engine lab at Moradabad Institute of Technology, Ram Ganga Vihar, Phase II, Moradabad, Uttar Pradesh (India).

Figure1: VCR Single Cylinder 4-S Engine Setup

Table 2: Specifications of Test Rig

Make and Model	Kirloskar-Oil Engine Limited
Engine Type	4 stroke, water cooled (TU I)
Number of Cylinder	Single
Bore	87.5 mm
Stroke	110 mm
Cubic Capacity	661 Cc (0.661liter)
Net Power	3.50 kw @ 1500 rpm
Compression ratio	12 to 18 :1
Max Speed	1500 rpm
Valves per Cylinder	Two
Number of nozzles	One (1)
Fuel injection type	Direct Injection
Max power	5.2 kw
Connecting rod length	234 mm
Orifice Diameter	20mm
Dynamometer arm length	185 mm
Rota meter	2 (engine and calorimeter)

Preparation of Blends

Three different blends of Pyrolysis Plastic oil and diesel were made by mixing both oils by handmade technique. Pyrolysis plastic oil is blended in 10%, 20% and 30% with pure diesel to prepare 500 ml of blended fuel at a time. These blends are termed as P10, P20 and P30. The percentage ratios of pyrolysis plastic oil and Diesel in blends are:

Table 3: Ratio of Oils in Blends

Blend Name	% of Oil in Blend	
	Pyrolysis Plastic Oil	Diesel
P10	10%	90%
P20	20%	80%
P30	30%	70%

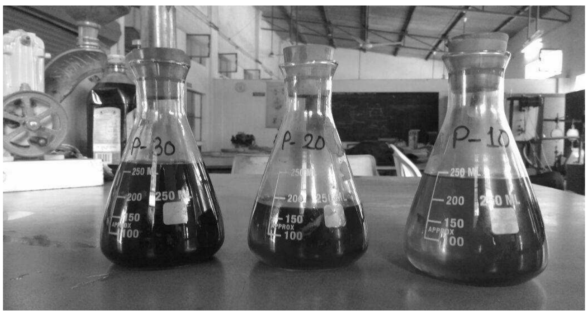


Figure 2: Fuel Blends of Pyrolysis Plastic Oil and Diesel Oil

EXPERIMENTAL PROCEDURE

- First Switch on power supply.
- Check water supply connections to engine and dynamo meter through rota meter.
- On fuel supply, if separate arrangement is done for storage & supply of biodiesel.
- The engine is started and warm up for 20 minutes.
- Start the computer and select the mode (configure) to enter the data.

- Select the run option.
- Each test is conducted and data is stored at five different loads, as on 0, 2, 4, 6, 8 load.
- Engine is run for 10-25 minute for one test and data available is stored by log key at the
- End of time interval.
- Next tests are conducted in sequence like pure diesel, P10%, P20% & P30%.

CALCULATION OF ENGINE POWER

The power developed by combustion of fuel inside the cylinder is known as Indicated power. The useful power available at the engine crankshaft is called Brake Power. Power lost in an internal-combustion engine through friction between parts of the machine itself is known as friction power or frictional losses. It is the difference between Indicated power and Brake power.

$$Ip = \frac{PimLAnk}{60000}\ kw$$

$$Bp = \frac{2\pi RFN}{60000}\ kw$$

$$Fp = Ip - Bp\ kw$$

P_{im} = indicated mean effective pressure,

L = length of the stroke

A = area of the piston,

n = number of power strokes per minute

K = number pf cylinders,

R = length of moment arm,

F = force

N = speed in revolutions per minute.

With the help of software engine power of pure diesel and different blends of pyrolysis plastic oil have been recorded at different loads.

Table 4: Engine Power at Different Load Conditions for Pure Diesel

Speed (rpm)	Load (kg)	IP (kW)	BP (kW)	FP (kW)	FP loss in %
1482.00	0.38	5.50	0.11	5.39	98.0
1488.00	2.18	5.65	0.62	5.03	89.0
1477.00	4.07	5.47	1.14	4.33	79.2
1467.00	6.17	5.43	1.72	3.71	68.3
1458.00	8.26	6.15	2.29	3.86	62.8

Table 5: Engine Power at Different Load Conditions for P10

Speed (Rpm)	Load (Kg)	IP (Kw)	BP (Kw)	FP (Kw)	FP Loss in %
1492.00	0.41	4.03	0.12	3.91	97.0
1474.00	2.21	4.65	0.62	4.03	86.7
1462.00	4.30	5.47	1.19	4.28	78.2
1456.00	6.19	4.86	1.71	3.15	64.8
1437.00	8.08	5.41	2.21	3.20	59.1

Table 6: Engine Power at Different Load Conditions for P20

Speed (Rpm)	Load (Kg)	IP (Kw)	BP (Kw)	FP (Kw)	FP Loss in %
1475.00	0.38	4.67	0.11	4.56	97.6
1474.00	2.28	4.67	0.64	4.03	86.3
1468.00	4.18	4.94	1.17	3.77	76.3
1454.00	6.19	5.27	1.71	3.56	67.5
1442.00	8.27	5.71	2.27	3.44	60.2

Table 7: Engine Power at Different Load Conditions for P30

Speed (Rpm)	Load (Kg)	IP (Kw)	BP (Kw)	FP (Kw)	FP Loss in %
1486.00	0.43	3.40	0.12	3.28	96.4
1472.00	2.21	4.02	0.62	3.40	84.5
1460.00	4.21	4.81	1.17	3.64	75.6
1446.00	6.20	5.32	1.70	3.62	68.0
1436.00	8.38	5.74	2.29	3.45	60.1

RESULT AND DISCUSSIONS

The indicated power developed using pure diesel is compared with different blends. It was noticed that indicated power for pure diesel is maximum at all loads conditions. The performance of P20 blended fuel is also very satisfactory. The indicated power of P20 is very close to pure diesel values.

In case of brake power diesel has the lowest power available at different load conditions compared to blends of Pyrolysis plastic oil and diesel. P20 fuel evaluation for different power was very best in comparison to other blends and its values were very close to pure diesel also. As there are some errors in load so constant load can’t be maintained due to which there is a minor variations in speed which affects the power output.

Frictional power loss starts decreasing after the continuous running of engine for few minutes. Load on the engine also affects the frictional power loss. The data shows as the load increases on the engine the frictional power losses starts reducing.

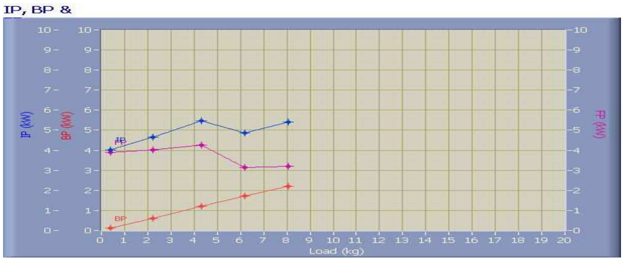


Figure 3: Graphical Representation of Engine Powers using Pure Diesel as Fuel

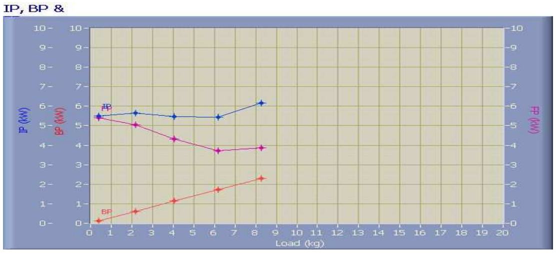


Figure 4: Graphical Representation of Engine Powers using P10 as Fuel

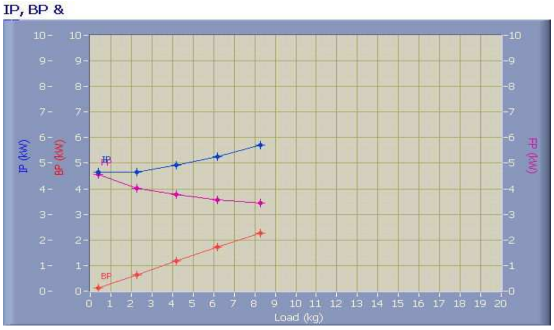


Figure 4: Engine Powers Using P20 as Fuel

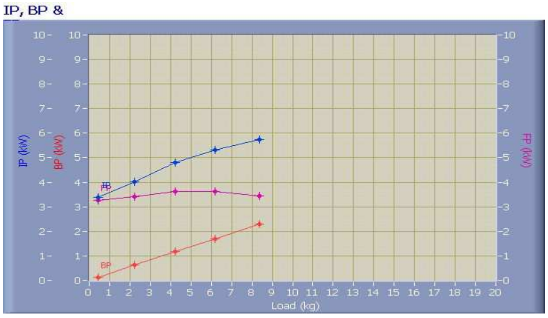


Figure 4: Engine Powers using P30 as Fuel

CONCLUSIONS

Pyrolysis plastic oil is the new alternate fuel for the future. It is easily available at low cost. It also saves our environment, to get polluted and soil from infertility. Plastic can be used as the future aspects, for all the domestic and industrial purposes. The optimizations of the blended fuels are required in future to know the exact volume of pyrolysis plastic oil in blend. The efficiencies and emission should also be considered, to maximize the use of Blended fuel as alternate fuel.

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